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THE SALMON OF SWIFTSURE BANK

AND

THE FRASER RIVER SOCKEYE RUN OF 1912.

BY

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APPENDIX.

THE SALMON OF SWIFTSURE BANK.

Hon. W. J. Bowser, K.C.,
Commissioner of Fisheries, Victoria, B.C.

SIR,—Salmon-fishing on Swiftsure Bank and in the Cape Flattery region generally did not begin on a large scale until the season of 1911, when the extensive use of power-boats enabled the troller and purse-seiner to operate with comparative safety on the off-shore banks. For a number of years prior to 1911 a small supply of salmon had been obtained from the Cape region, and either marketed fresh or canned at Port Angeles or Port Townsend. Originally, these were taken by Indians who obtained them trolling, for the most part near shore. In 1908 white trollers appeared and have since steadily increased in numbers. The maximum output during this early period has been estimated at approximately 15,000 cases, in addition to a small amount marketed fresh.

In the season of 1911, for the first time, purse-seiners operated in the Cape region and were accompanied by an unprecedented number of trollers. There are said to have been in commission about twenty-two seine-boats and perhaps 250 trollers. No close estimate can be made of the total output of the district during 1911. The best figures available indicate 850,000 cohoes or silver salmon, and an equal number of pinks or humpbacks. No record is obtainable of the spring salmon, but it is safe to assume that they were taken in about the small proportion as existed in 1912. Sockeyes and chums or dog-salmon were taken in very small numbers.

Finally, in 1912, over 100 purse-seine boats were operating out of Neah Bay at one time, with a total for the season of probably over 125. There were probably 400 or 450 trollers at work some time during the season. But the total yield of the Bank was less than for 1911, in spite of the great increase in amount of gear. This was due in part to the fact that 1912 was an off-year for humpbacks, partly perhaps to unfavourable weather, but in part, without question, to the diminished run of cohoes or silver salmon. Over 100 purse-seiners in 1912 failed to increase, if indeed they equalled, the catch of cohoes made by twenty-two purse-seiners in 1911.

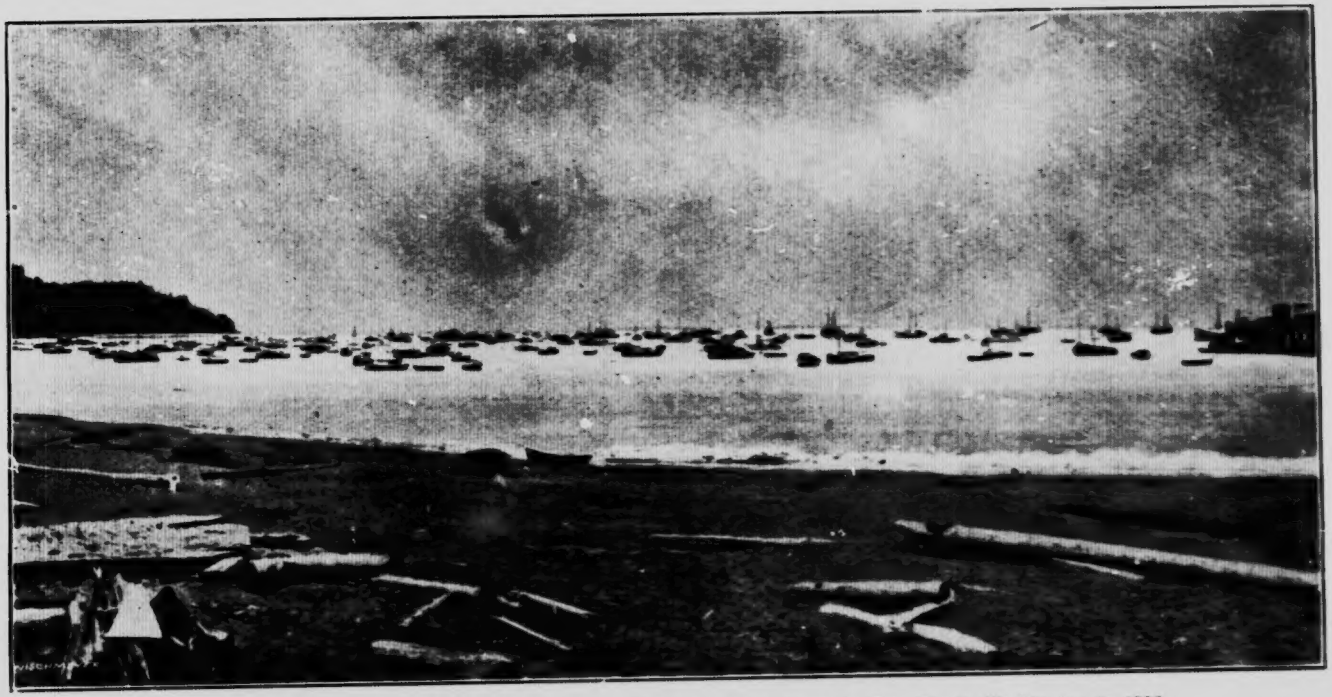
Figures obtained from all the canneries known to have handled fish from Swiftsure Bank and the Cape in 1912 give the following totals:—

Spring salmon	47,434
Sockeyes	12,711
Cohoes	822,798
Humpbacks	3,324

Figures were not available for spring salmon marketed in a fresh condition, and such are not included above. Making a reasonable allowance for these and for those of other species that failed to be enumerated or that perished in transit, we have:—

Spring salmon	90,000
Sockeyes	15,000
Cohoes	840,000
Humpbacks	5,000
Total	950,000

This total agrees with that independently obtained by Mr. W. I. Crawford, secretary of the Puget Sound Canners' Association, who has kindly furnished us with much valuable information, and to whom our thanks are due.



A part of the Swiftsure Bank Salmon Fleet at anchor in Neah Bay, Juan de Fuca Strait, Washington, in 1912.

Various theories are held by fishermen and dealers as to the source and the destination of the salmon which school on Swiftsure Bank. Some claim they come in from the south and are migratory species bound north for Alaskan waters. As regards the direction whence they approach the Bank, we have nothing to offer; but it can be asserted with a very high degree of probability that all of them are bound up the Straits of Fuca to spawn in the Fraser River or in the streams tributary to Puget Sound. This can now be considered demonstrated as regards the sockeyes and humpbacks, for the periodicity in their runs which these species exhibit in the Puget Sound District, and not elsewhere, is perfectly marked on Swiftsure Bank. Thus we have seen, there was an enormous run of humpbacks on the Bank in 1911, when this species ran heavily on the Sound, whereas it was almost wholly lacking on the Bank in 1912, the off-year for the Sound. It is safe to predict that it will run heavily again on the Bank in 1913 and be almost lacking in 1914. No observations have yet been made of the abundance of sockeyes on Swiftsure Bank during a season of heavy run. An opportunity for such an observation will offer for the first time during the summer of 1913, when we may confidently anticipate a much larger catch than was made in 1911 or in 1912. But the Fraser River run can be detected just as certainly in any part of its course during the year before the big run. For it is then marked by enormous numbers of small precocious males, known as "grilse," whereas in all other streams and in the other three years of the Fraser River cycle the grilse are present in such small numbers as not to attract attention. A heavy run of grilse was due, therefore, in 1912, and wherever the Fraser River sockeyes were captured, whether in the Gulf of Georgia, on the Salmon Banks, or along the southern coast of Vancouver Island, the grilse were, in fact, found to constitute numerically a surprising proportion of the total catch. On Swiftsure Bank the same was true, the grilse constituting numerically from 15 to 20 per cent. of the total catch. This fact alone was sufficient to identify the Bank fish completely as a part of the Fraser River run.

The spring salmon taken on Swiftsure Bank can also be identified by those familiar with the Puget Sound run. The Fraser River race, with its short, bluntly rounded head, tender red flesh, and soft bones and cartilages, familiar to the trapmen of the Gulf of Georgia, the Salmon Banks, and the west coast of San Juan Island, can be easily distinguished on Swiftsure, and runs there in varying proportions in different parts of the season. The other springs taken on the Bank agree in appearance with those bound for the streams of Puget Sound, with long sharp noses, paler firmer flesh, and harder bones and cartilages. Here, again, we can entertain no doubt that the spring salmon also are schooling on the Bank temporarily, and are headed up Sound to the streams in which they will spawn and die.

As regards the destination of the cohoes, which constitute so large a proportion of the yield of the Bank, conclusive evidence is lacking, due, no doubt, to the fact that these fishes have been less investigated than the sockeye and the spring salmon, so we are not yet in a position to recognize their local races and the streams for which they are bound. In the early part of the season the cohoes taken on the Bank differ so strikingly from those taken later in Puget Sound that the majority of the canners consider them a distinct fish. They average much smaller in size, have redder meat, and are so soft that it is difficult to bring them from the fishing-grounds in fit condition for canning. But as regards both size and consistency, there is a gradual change in the Bank cohoes, the fish becoming both larger and firmer as the season advances. The increase in size is made evident by all cannery records, which give the number of fish per case at intervals through the season. The one given below would be still more striking did it contain the first of the run:

July 23rd	13.35	cohoes	to the case.
August 4th	11.55	"	"
" 12th	10.08	"	"
" 23rd	9.65	"	"
" 30th	8.06	"	"
September 2nd	7.56	"	"

Another record is as follows:—

July 6th	14.16	cohoes	to the case.
August 9th	11.14	"	"
" 19th	10.00	"	"

The small size and different consistency of the Bank cohoes are evidently phenomena associated with their growth and manner of feeding, and do not mark them off from the fish of Puget Sound.

All the cohoes taken on the Bank are in their third year and will mature and die during that season. Those captured during the summer of 1912 had been spawned in the winter of 1909-10, and had lived in their native stream until the spring of 1911, when they descended to salt-water, at a length of 3 or 4 inches. During that summer they grew rapidly, and by September had attained a length of 6 to 14 inches. Their further growth during the winter of 1911-12 has not been fully traced, but it is these same fish which appeared on Swiftsure Bank the following spring and attained full size and maturity during that season. Much the greater part of their growth is attained, therefore, in their third and last year, so it is not surprising that those first seen in the early summer are small and immature in comparison with the same fish two or three months later.

Food of Swiftsure Bank Salmon.

All species of salmon are feeding voraciously on Swiftsure Bank, even including the sockeye, the feeding habits of which have been hitherto unknown. Although thousands of sockeyes had been examined from the mouth of the Fraser, the Gulf of Georgia, the Salmon Banks, and even from the westernmost traps on Vancouver Island, no trace of food had been found in the stomachs. This had led to the theory that the Fraser River sockeye come annually from some distant feeding-ground and begin fasting as soon as they start on their shoreward migration. But during the past summer it was observed by Mr. J. P. Babcock and the writer that the sockeye on the Bank were feeding extensively on a small shrimp-like crustacean (*Thysanoëssa spinifera*, Holmes*), which floats in incredible numbers on the tides and forms a favourite food for the other species of salmon as well as the sockeye. These floating organisms often form brownish masses at or near the surface and are considered to give certain indication of the presence of salmon. Every specimen of sockeye examined at the Bank had been feeding freely on these crustaceans, but whereas the spring salmon and the cohoes frequently contained herring and other small fish, no trace of these were found in the sockeye. This distinction in diet is not improbably a permanent one, though further observations are necessary to establish it. The springs and cohoes have large teeth, and the appendages or strainers on the gill arches are short, few in number, and coarse. These are characteristic of predaceous fish, and doubtless indicate a preference for the larger and more active prey. But the sockeye, as is well known, has but few minute teeth, so that it frequently passes for toothless, and is further characterized by the numerous, long, slender, and close-set strainers of the gill-arches. It should occasion no surprise, therefore, to discover that it feeds principally, or even exclusively, on the smaller pelagic organisms.

This discovery of Fraser River sockeyes feeding normally at the entrance of the Straits of Fuca is an important one, with a bearing on the probable life of this species in the sea. It is no longer necessary to postulate for them a distant mysterious residence where they feed on some equally mysterious diet. We are at liberty to believe that the young, on passing out from the Straits, may distribute themselves in the adjacent sea, and during the years of their growth may wander far or near in search of food, reassembling off the Straits when approaching maturity leads them back toward their natal stream. Neither in the case of the sockeye nor in that of any other species is there any basis for assuming a definite migration in the sea, either north or south, and a longitudinal movement along the coasts. More probably there is something in the nature of a fan-like dispersal of young from the mouths of their native streams, and a reverse movement as spawning-time approaches.

The favourite fish-food of the spring salmon and the cohoe is the sand-lance (*Ammodytes personatus*, Girard), known locally as "candle-fish." Another species of *Ammodytes* is the preferred food of the Atlantic salmon. Where the sand-lance abounds in the Straits of Fuca, it is chosen by young and old to the almost total exclusion of other diet. None were seen on Swiftsure Bank, where the numerous species taken from the stomachs seemed to indicate that choice was largely determined by available size and by ease of capture. Herring and smelt were most frequently seen, but the larger spring salmon may even devour the hake and species of similar size. The principal food of all, however, is the small crustacean previously

* For the identification of these specimens and for other facts in that connection, we have to thank the kindness of Miss M. J. Rathbun, of the United States National Museum.

mentioned. There is no reason apparent why these should occur in special abundance in the vicinity of a submarine bank. They are pelagic or free-swimming throughout life, the eggs float freely in the water and hatch out in free-swimming larvæ, which at no stage in their development have any necessary relation with the bottom. The depth which this species may inhabit is unknown. The closely related Atlantic form (*Thysanoëssa inermis*, Kröyer) is found in the upper water layers, from the surface down to 100 fathoms, but whether deeper than 100 fathoms has not been ascertained.

ECONOMIC ASPECTS OF THE FISHERY.

Before the recent phenomenal development of the purse-seine fishing fleet, Puget Sound and adjacent waters were already too closely fished, with serious inroads already made on the three most valuable species—the sockeye, the spring salmon, and the cohoe. In their long journey through Straits and Gulf, they had to run an ever-lengthening gauntlet, with the result that the breeding stock became yearly so depleted that it was inadequate to keep up the supply. The recent discovery that the salmon school in large numbers on Swiftsure Bank adds one more point of attack and threatens annually to diminish the advancing schools by another million fish. This in itself is regrettable, but might not furnish adequate grounds for prohibiting the fishing, even were it ascertained that effective supervision of the Bank could be exercised. For it might be justly urged that, even though an additional million fish threatened the industry, there was no reason why Swiftsure Bank should not be permitted to furnish its quota of whatever total number could rightly be spared.

There are at least two other reasons, however, why the capture of salmon on Swiftsure Bank is ill-advised and involves a serious economic waste not encountered elsewhere. In the first place, the salmon there captured, especially in the first part of the season, are far from having attained their full growth, although maturity is but a few months distant. The most valuable product of the Bank is the cohoe, which would gain about 100 per cent. of its net weight if it could be permitted to grow throughout the season, and could be taken on fishing-grounds up the Sound, when mature in the fall.

A further objection lies in the well-known fact that the condition of the salmon taken on the Bank from the beginning of the season to near its close is such that the majority of the canners would perfer not to handle them. This is pre-eminently the case with the cohoe, but is unmistakably true also with the spring salmon. The flesh is peculiarly soft and pulpy, so that it rapidly deteriorates, and the abdomen is commonly distended with crustacean food, which quickly breaks down and infects the adjacent tissue. As a result, even when handled with the customary care, salmon from the Bank may become in less than twenty-four hours from their capture the very reverse of attractive. The abdomens may be broken open, the ribs protruding freely, and the flesh may have begun to deteriorate. Even the canneries most favourably located to handle this product were forced to adopt extraordinary precautions. Those at a great distance, while forwarding the fish with all possible expedition, sometimes received them in very poor condition. Now and again, a part of the consignment would have to be rejected. Occasionally, it is to be feared, it found it way into tins to which a pure-food law might well have taken exception.

Not only, then, is there an economic waste in catching the smaller fish on Swiftsure Bank so early in the season but there is an economic crime in handling them at such time and place that there must result a product very inferior, if not actually dangerous to health. We cannot resist the conclusion that it would be far better for the industry if fishing on the Bank could be entirely discontinued.

The above statements concerning the small size and unfavourable condition of the Bank salmon refer, as has been said, pre-eminently to the cohoe, which in most years form the most valuable component of the catch. This species spawns very late in the fall and winter, and continues to feed voraciously and to grow up to the time of entering the streams. Of the valuable species which frequent the Bank, it is therefore the smallest and most immature in the early part of the season.

The sockeye, on the other hand, has practically attained its full growth on reaching the Bank, and the flesh is not conspicuously softer then when captured elsewhere. No young sockeyes, save the precociously mature male grilse, were seen. The species occurs on the Bank in off-years in such relatively small numbers as to have during those years no effect on the sockeye run.

The spring salmon is taken in large numbers and furnishes a somewhat inferior product, with soft flesh, little oil, and poor colour. Several thousand young of this species are captured during the season, two-year-olds, about a foot long, with white soft flesh—a total waste. The numbers of these are relatively small, as the great majority of the salmon on the Bank are in their last season, but the loss is nevertheless serious and deplorable.

I have, etc.,
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Victoria, B.C., September 1st, 1912.

THE FRASER RIVER SOCKEYE RUN OF 1912.

Hon. W. J. Bowser, K.C.,
Commissioner of Fisheries, Victoria, B.C.

SIR,—Prior to 1910, when the writer first developed the method of determining the age of Pacific salmon by the seasonal grouping of the delicate rings marking the surface of the scales (*see* page I 57), it had been generally accepted that Fraser River sockeye mature invariably in their fourth year. This theory was based on the well-known fact that very heavy runs enter the Fraser every fourth year, with much lighter runs in the intervening years, a condition which has existed as far back as we have any definite records. The theory of a four-year cycle for the sockeye seemed, therefore, well founded, and it became a matter of extraordinary interest to test the theory by independently determining the age of a number of individuals belonging to the spawning run.

On doing this, it became at once apparent that the majority were four years old and hence in accord with the theory. But the smallest members of the run (almost invariably males) were but three years old, while a considerable number of the larger fish were unmistakably in their fifth year. In view of these facts, it became important to inquire how the predominance of every fourth year had been so long maintained. For if the progeny of a big year should mature and return to the river partly in three, partly in four, and partly in five years, it would seem there should be a tendency to increase the runs in the third and fifth years of the cycle, as well as to maintain that of the fourth year; and as this tendency would be constantly operative and cumulative, it should eventually distribute the benefits of the "big years" equally among the others.

On consideration, however, it becomes obvious that the three-year fish, or grilse, can be eliminated from the problem. For inasmuch as practically none of these are females, and as the males can be considered purely supplementary, being of small size and not needed on the spawning-beds, it is evident they add nothing to the progeny of any year in which they are more than usually numerous.

But the case would appear otherwise with the five-year fish. Among these, both males and females are present in not very unequal numbers, and with these the females average larger than the four-year females and produce a greater number of eggs. If, therefore, any constant percentage of the progeny of a big year matures in its fifth rather than its fourth year, this should have its evident effect on the fifth year of the cycle. Such an effect thus far has not been determined. It would be impossible to separate the two ages by their appearance, for, although the five-year fish average larger, the two ages wi. y overlap in this regard. An analysis of the run by the aid of the scales is necessary to decide this point, and must extend over a number of years, until we shall have ascertained whether the proportion of the progeny which delay maturing until their fifth year is a relatively constant one, or whether it fluctuates so widely for unknown reasons that we are unable to predict the outcome in any given case. If the proportion is relatively constant, then we can predict the run with some assurance in any year, if we know the success of natural and artificial propagation in the fourth and the fifth years preceding. But if the proportion varies widely in different years, this would introduce a disturbing factor which might bring propheay to naught, especially in the years of small run.

Thus, if 1914, 1915, and 1916 should have approximately equal runs and should present equally favourable conditions on the spawning-beds and in the hatcheries, nevertheless the corresponding years of the next cycle might from this cause exhibit very unequal runs. If, for example, 5 per cent. of the progeny of 1914, 45 per cent. of 1915, and 20 per cent. of 1916 should mature in their fifth year, then the run of 1919 would be made up of the 5 per cent. five-year-olds from 1914 and 55 per cent. four-year-olds from 1915; while the run of 1920

would contain 45 per cent. five-year-olds from 1915 and 80 per cent. four-year-olds from 1916. The latter would be more than twice as large, therefore, as the former. It is thus highly important to establish the constancy or the variability of the age factor, for to establish this will bring us one step nearer the possibility of predicting future runs.

As a contribution to this end, it was attempted to analyse the run of 1912 into its age components, and to compare the results with those secured by the writer in 1911, when this method was used for the first time.

THE GRILSE.

In 1911 the number of three-year-olds or grilse were so small as to be almost negligible. No attempt was made to determine the very limited proportion in which they occurred, as it was difficult to secure enough specimens for examination. It should be recalled that the grilse of 1911 were developed in their due proportion from the comparatively few eggs deposited in the "off-year," 1908.

In 1912 the case was far different. The grilse of that year were derived from eggs laid down in the big year 1909, and from the first of the season to its conclusion, wherever the Fraser River run was intercepted, the large number of small three-year fish was at once apparent. Several attempts to estimate the proportion of grilse to full-grown fish were made August 4th to August 7th, by enumerating them as they passed along the conveyor at the cannery of the Pacific American Fisheries at Bellingham, Washington. The results of the different trials were as follows:—

Proportion of Sockeye Grilse in Fraser River Run of 1912.

	Total Number.	Number of Grilse.	Proportion of Grilse.
August 4th	1,445	270	18.6 per cent.
" 4th	8,200	1,900	23.4 "
" 4th	771	200	25.9 "
" 4th	10,426	2,370	22.7 "
" 6th	5,318	1,166	21.9 "
" 7th	7,189	1,182	16.4 "
" 7th	6,115	1,400	22 9 "
Totals	39,464	8,488	21.5 per cent.

Other less extensive tests were made at different localities and at various times during the season, and were all in close agreement with the above, It seems safe to conclude, therefore, that in the Fraser River sockeye run of 1912 about one fish out of every five was a small three-year-old precocious male. The grilse were thus about half as numerous as the males of the full-grown fish.

In length, the grilse varied from 16½ to 21½ inches long, as shown in the following table, in which are included 500 individuals taken at random:—

Length in Inches of 500 Grilse Sockeyes.

Length in inches	16½	17	17½	18	18½	19	19½	20	20½	21	21½
Number of specimens	1	15	25	77	95	112	96	44	22	11	2

The average length is 19 (18.9) inches. The weight varies from 1¾ to 4 lb., the average being 2¾ lb. The flesh is lighter in colour and liberates less free oil than the full-grown individuals, and is commercially less valuable. In addition, there is greater waste in cleaning. To test this, ten grilse averaging 2⅓ lb., ten medium-size sockeyes averaging 5⅕ lb., and ten of larger size averaging 7⅕ lb., were cleaned by the usual process, including the use of the "Iron Chink." When ready for the tins, the grilse had lost 27.1 per cent., the fish of medium size, 24.6 per cent., and the larger size 22.7 per cent. of their weight. The grilse are therefore

not a very valuable component of the pack. In former seasons, when fish were abundant and cheap, they were very generally rejected, or were put up separately as a cheaper grade. But in 1912 they were generally, though not universally, included with the rest of the sockeye pack.

The scales of several hundred grilse were examined in an attempt to discover some event in their past history which could aid in explaining their precocious development, but without success. The vast majority of them had remained in the lake in which they were hatched until their second spring, as is the case also with the fish which mature in their fourth and fifth years. They had grown at the same rate as the latter in the first and the subsequent years. The factor which determines the age at which maturity is attained is unknown, and has not as yet been correlated with any peculiar habit or set of external conditions. This is in accord with our observations on salmon reared in aquaria. A thousand young spring or chinook salmon, hatched and reared in a single aquarium, in which conditions are as nearly uniform as they can be made, will include at the close of their first summer a number of precociously developed males, capable of furnishing functional milt. While such males are perhaps more frequently found 5 or 6 inches long, among the larger individuals of the colony this is by no means invariably the case. A number have been observed not exceeding 3½ inches long. It is evidently, then, not a matter of simple nutrition.

FULL-GROWN SOCKEYES.

For comparison with the adult sockeyes constituting the main element of the 1912 run, we have only a similar examination made by the writer in 1911. The results in the two years are widely dissimilar. In 1911, out of a total of 500 individuals examined, 271, or 54.2 per cent., were maturing in their fourth year, and 229, or 45.8 per cent., in their fifth year. Almost half of the pack of 1911, therefore, was composed of individuals five years old, derived from eggs deposited in 1906. It is apparent how impossible it would have been to predict accurately the run of 1911, as has been heretofore attempted, solely from the condition of the spawning-grounds and hatcheries four years previously—that is, in 1907.

But in 1912, the number of five-year fish was so small as to be almost negligible. Five hundred individuals, examined July 29th, at the cannery of J. H. Todd & Sons at Esquimalt, B.C., were distributed as shown in the following table:—

Five Hundred Adult Sockeyes of the 1912 Run, grouped by Age, Sex, and Size.

Length in Inches.	Number of Individuals.			
	Four Years Old.		Five Years Old.	
	Males.	Females.	Males.	Females.
21½		1		
22	2	1		
22½	3	1		
23	4	11		
23½	10	22		
24	41	36		
24½	37	62		2
25	55	51	1	3
25½	27	19		6
26	35	9	5	6
26½	22	1	1	4
27	5		6	4
27½			2	
28			2	1
28½			2	
29			1	
Total	240	214	20	26

As will be noted, 454, or 90.8 per cent., were four-year fish, and only 46, or 9.2 per cent., were in their fifth year.

On August 5th a second lot of 500 were investigated at the cannery of the Pacific American Fisheries at Bellingham, Wash., with results as follows:—

500 Adult Sockeyes of the 1912 Run, grouped by Age, Sex, and Size.

Length in Inches.	Number of Individuals.			
	Four Years Old.		Five Years Old.	
	Males.	Females.	Males.	Females.
22	.....	1	.....	.....
22½	2	1	.....	.....
23	1	1	.....	.....
23½	9	14	.....	.....
24	15	15	.....	.....
24½	33	49	.....	.....
25	43	52	.....	2
25½	47	33	2	3
26	41	21	3	5
26½	23	11	5	8
27	21	1	1	8
27½	6	1	3	.....
28	3	.....	4	1
28½	1	.....	6	.....
29	.....	.....	3	.....
29½	.....	.....	1	.....
Total	445	200	28	27

In this case, 445, or 89 per cent., were in their fourth year, and 55, or 11 per cent., in their fifth year.

A third trial was made August 6th at Bellingham, as shown in the following table:—

Five Hundred Adult Sockeyes of the 1912 Run, grouped by Age, Sex, and Size.

Length in Inches.	Number of Individuals.			
	Four Years Old.		Five Years Old.	
	Males.	Females.	Males.	Females.
21	.....	1	.....	.....
21½	.....	.....	.....	.....
22	.....	2	.....	.....
22½	2	2	.....	.....
23	6	11	.....	.....
23½	7	13	.....	2
24	25	36	1	.....
24½	40	53	.....	2
25	45	50	2	6
25½	54	31	1	5
26	31	13	1	3
26½	15	4	1	5
27	9	.....	6	.....
27½	3	.....	7	1
28	1	.....	.....	.....
28½	.....	.....	1	.....
29	.....	.....	.....	.....
29½	.....	.....	2	.....
Total	238	216	22	24

The result was here identical with that obtained at Esquimalt, 454 (90.8 per cent.) being four-year-olds, and 46 (9.2 per cent.) five-year-olds. The Bellingham fish were taken in traps and with purse-seines on the salmon banks and in the Gulf of Georgia, and the Esquimalt fish

in traps located on the southern shore of Vancouver Island, west of Victoria. The close correspondence of these three tests is sufficiently remarkable, and indicates beyond question that at the time the examination was made the run consisted everywhere of a homogenous mixture of four- and five-year fish in definite proportions, nine of the former to one of the latter. The 1,500 examined gave altogether 90.2 per cent. four-year-olds and 9.8 per cent. five-year-olds.

The causes of the great disparity shown in 1911 and 1912 in relative numbers of four- and five-year fish cannot yet be assigned with certainty, but are to be looked for in conditions which existed in 1906, 1907, and 1908, the small years of the preceding cycle. The following may be suggested as possibilities:—

(1.) It is possible that an abnormally large proportion of the 1906 generation may have delayed maturing until their fifth year. Had this occurred, it should have diminished the size of the run four years subsequently in 1910, and should have materially increased the run of 1911. It is a valid objection to the theory that 1910 gave an average yield, in the present condition of the industry, while 1911 was the poorest for many years.

(2.) An alternative theory is to the effect that the season of 1907 may have brought to the Fraser River spawning-beds so small a number of sockeyes that their progeny, which matured part as four-year fish in 1911 and part as five-year fish in 1912, would both be present in very limited numbers. This would explain the heavy percentage of five-year fish in 1911, as well as the light run of that year, and would explain the abnormally light run of five-year fish in 1912. Its influence on the total size of the run of 1912 would be far less than in 1911, if, as we suppose, the total number of five-year fish produced from any given batch of eggs is much below the number that mature in four years. This theory would then of itself explain all the facts, without having recourse to the first suggested above, or to any further hypothesis.

It becomes, then, of unusual interest to recur to the condition of the spawning-beds on the Fraser River in 1907, as given in the Report of the Commissioner of Fisheries in that year. While the hatch, both natural and artificial, had been larger in 1906 than during any off-year of the preceding cycle, we learn that the reverse was true in 1907. In the report of that year, Mr. J. P. Babcock writes (p. 9): "From an inspection of the spawning-grounds of the Fraser and its tributaries, I find that a smaller number of sockeye reached them this year than in any one of the past seven seasons. . . . While the number of eggs secured this year exceeds by six millions those gathered last year, *the number which spawned naturally was insignificant.* A competent observer who lives on the Birkenhead River, the principal stream of the Harrison-Lillooet Lake Section, states that there was not one sockeye there this year for every ten last year. In the Shuswap-Adams Lake Section the run of sockeye this season was small. . . . To the Quesnel Lake Section, the run of sockeye consisted of only a few hundred fish, and none were observed in the Horsefly. The run to Stuart and Chilco Lakes was the smallest ever reported." (Italics mine.)

It seems highly probable, therefore, that the percentage of five-year fish observed in the run of 1911 (45.8 per cent.) was abnormally high, due to the unusually small number of four-year fish which resulted from the lean year 1907; and, further, that the proportion of five-year fish observed in the run of 1912 (9.8 per cent.) was abnormally low, owing again to the small yield of 1907. If there prove to be a relatively constant ratio between the four- and the five-year fish which develop from any given batch of eggs, such ratio will probably be found between the extremes given by these two years. But the year 1913 cannot be expected to throw any light on this question, as the enormous numbers of a big year must consist in overwhelming proportion of four-year olds.

The average weight of the 1912 run agrees closely with that obtained in 1911, though the latter was from less abundant data. As is shown by the following table, the average for four-year fish was 5.98 lb. (6.27 in 1911); for five-year fish, 7.38 lb. (7.46 in 1911):—

Five Hundred Fraser River Sockeye Run of 1912, grouped by Weight and Age.

WEIGHT IN POUNDS.	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½
Four-year-olds	1	19	52	107	120	86	38	13	7	6	2	.....
Five-year-olds	.....	.....	1	3	3	4	10	12	7	4	3	2

It will be noted that neither in length nor in weight is there any considerable overlapping between grilse and the older fish. Of 500 grilse examined, only two reached a length of 21½ inches and a weight of 4 lb. Of 1,500 adults, only two were as small as 21 and 21½ inches long, respectively, and only one weighed as little as 4 lb. This does not include two highly emaciated and obviously abnormal females, 20½ and 21 inches long, of the same size as male grilse, but four years old. They were evidently dwarfed by malnutrition, but they had successfully matured their eggs. No female grilse were seen in 1912.

No attempt will be made here to discuss in detail the early history of individuals comprising the 1912 run of sockeyes, as we infer it from the structure of their scales. But certain differences were obvious when comparison was made with the run of the previous year. In 1911 there was a number of interesting individuals having scales distinguished by large centres with widely spaced rings. These were interpreted as having migrated oceanwards immediately on reaching the free-swimming stage. In the run of 1912 there was an almost total absence of this form. Practically the entire run had developed from fingerlings which spent their first year in fresh water. The centres of the great majority of scales exhibited a structure identical with that found in migrating yearlings, taken in the early spring in the Fraser. The number of rings varied from seven to twenty; the outermost rings intimately crowded, tenuous, and usually more or less broken and interrupted. Immediately beyond them, begin abruptly the wide rings which signal the rapid growth of the second spring, begun either while still in the lower reaches of the river—in which case an intermediate zone is formed—or later after they have reached the sea. A very small percentage, however, do not entirely agree with the above, and have not been satisfactorily accounted for. Their scales have the centres with closely crowded rings as in those noted, but the nuclear area is larger than the scales of any yearlings yet captured on their downward migration. The rings may be as numerous as thirty to thirty-five in number, but give no indication of more than one year having been spent in the lake. Two alternative theories suggest themselves. Either these remained in their native lake for one year, like the others with similar but smaller scale centres, and represent exceptionally large individuals which have thus far eluded capture on their seaward migration; or they ran to sea immediately on reaching the free-swimming stage, but found the conditions in the ocean less favourable than in other years, and hence failed to reach the usual size for yearlings in the sea. The first of these seems the more probable hypothesis.

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